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SWORDFISH TRACKING IN THE SOUTHERN CALIFORNIA BIGHT

By

David B. Holts, Norman W. Bartoo, and Dennis W. Bedford

ADMINISTRATIVE REPORT LJ-94-15

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Billfish and shark resources along the west coast of the U. S. and Mexico are important to both commercial and recreational fisheries (Hanan et al. 1993, Cailliet et al. 1993, Holts and Bartoo 1990, Bartoo and Coan 1989). In the late 1970's and early 1980's, these resources came under increased fishing pressure from the California drift gill net (DGN) fleet targeting swordfish, *Xiphias gladius*, and thresher sharks, *Alopias vulpinus*, (Holts 1988, Bedford and Haggerman 1983). Fishing effort centered in the coastal waters off southern California and peaked from 1982 to 1986 with 9,000 to 11,000 net sets per year (Hanan et al. 1993).

Several problems and fishery conflicts occurred during the development and expansion of the DGN fishery. The by-catch of striped marlin, *Tetrapturus audax*, and other gamefish was a major concern to the sport industry while the commercial harpoon fishery for swordfish viewed DGN's as unfair competition. Environmental groups vigorously protested the by-catch of marine mammals and other non-target species. The effect of these conflicts, to a lesser or greater extent, resulted in changes to nearly every aspect of the fishery including: boats and gear, techniques and regulations, fishing areas, seasons and targeted species.

As the catch of southern California's billfish and shark resources increased through the mid-1980's some fishery biologists became concerned that certain populations may not be able to sustain such levels of fishing pressure. There were, in fact, early signs that some species, especially sharks, were being harvested at rates beyond their carrying capacity (Bedford 1987, 1985).

At that time very little was known about the population size, stock structure, distribution or movements of most of these target species involved. Commercial and recreational fishery data indicated three of the top piscivorous predators were all seasonally most abundant in the southern California waters during the months of about April through November. Little else was known concerning the short term behavior of individuals. Acoustic telemetry had, at that time, become useful in identifying many of the behavior patterns and physiological characteristics that influence habitat preference of large free swimming pelagic fish (Brill et al. 1993, Holts and Bedford 1993 & 1990, Nelson 1990, Holland et al. 1986, Carey and Scharold 1990, Carey and Robison 1981, Carey and Olson 1981, Yonemori 1982, Yuen 1970, Yuen et al. 1974).

A cooperative research project between the Tuna-Billfish Assessment Program, Southwest Fisheries Science Center, and the California Department of Fish and Game (CDFG) was undertaken from 1986 to 1989 for the purpose of investigating the seasonal distribution, short-term movements and habitat of the large pelagic predators involved in these fisheries. That project focused on both target and non-target species was successful in tagging and tracking with acoustical transmitters 11 striped marlin, 3 shortfin mako sharks, *Isurus oxyrinchus*, and one swordfish. Results have previously been reported for striped marlin (Holts and Bedford 1990) and shortfin mako sharks (Holts and Bedford 1993). This report presents the tracking data from the single swordfish track.

METHODS

The 18 m sport fishing vessel, *Pacific Clipper*, was chartered for the project. The acoustic tracking techniques and equipment used in this study were previously described for tracking striped marlin and shortfin mako sharks. This involved the use of a hull mounted, directional hydrophone and receiver (Vemco[1], CS 40 and VR 60 respectively) to indicate direction and distance to the tagged shark. The acoustic transmitter tags (Vemco V4P[1]) used for the swordfish had a working pressure of 500 psi (maximum depth 340 m). The tracking vessel remained within 400 m of the fish and loran-C coordinates were recorded every 15 minutes for horizontal positioning and to determine periods of increased or decreased activity. Temperature profile of the water column was measured with expendable bathythermographs (XBT) approximately every 6 hours.

RESULTS AND DISCUSSION

On November 8, 1986 a swordfish was observed finning at the oceans surface half way between Santa Catalina Island and Dana Point, California (Figure 1). The sonic transmitter was given to a commercial harpoon fisher working in the area who had previously agreed to assist with our project. The swordfish was estimated to weigh 91 kg and was harpoon tagged at 1309 hrs. The swordfish immediately descended to a depth of 50 m where it remained for about 25 minutes. During the next 24 hours it traveled in a broad arc that took it over the "14-mile Bank" (Lasuen Knoll) covering approximately 31.5 nm (Figure 1).

As the swordfish proceeded from the tagging location, it slowly increased its speed from about 0.7 nm h to nearly 1.5 nm h by sunset. Following sunset, its speed decreased until 2145 hrs when it again increased its speed to at least 2.5 nm h for nearly an hour. The swordfish increased its speed at about 0300 hr and appeared to be moving directly toward the 14-Mile Bank. Its speed decreased from a high of over 2.5 nm h to less than 1.0 nm h indicating it may have begun foraging at or very close to the bottom.

This fish spent essentially all of the time below 10 m and approximately 75% of the track time in or just below the mixed layer. It twice descended below 320 m (Figure 2). Time

[1] Reference to trade names does not imply endorsement by NMFS.

spent in each temperature band is indicated in Figure 3. It spent 17 % of its time during the two dives at depth where the temperature was 8° C, a full 8° C below the mixed layer temperature. During both deep dives the swordfish made rapid descents from 45 m to over 320 m. The swordfish spent considerable time (1.5 and 3.5 hrs.) at depths over 320 m. Both dives were marked by abrupt descents (and ascents) which is remarkable considering the physiological stress from changes in water temperature and pressure. This constituted a change in ambient pressure from 80 psi to over 570 psi and temperature change from 14° C to 8° C. Dissolved oxygen[2] in the water decreased from 5.5 ml/l at the surface to 1.6 ml/l at 300 m and the salinity[2] increased from 33.39 ppt to 34.19 ppt. The first deep dive occurred in the late afternoon and lasted about 90 minutes during which it maintained a speed of 1.0 to 1.5 nm h. The water depth was nearly 700 m. The second deep dive started at 0845 hrs the following morning and lasted just over three hours. This particular dive occurred over a small bank called "14 Mile Bank" that reaches to within 104 m of the surface.

The track indicates the diel behavior of this swordfish is consistent with that pattern reported for swordfish by Carey (1990) and Carey and Robison (1981). Our tracks suggest that swordfish, like striped marlin and shortfin mako sharks spent nearly all of the night time hours at depths less than 50 m. Shallow vertical excursions were more numerous at night than during day light hours with deep dives occurring prior to sunset and after sunrise. Other than the first sighting and subsequent tagging, the basking behavior described by Carey and Robison (1981) was not observed in this fish. The direct path and speed this swordfish took toward the 14-Mile Bank suggests some navigational ability.

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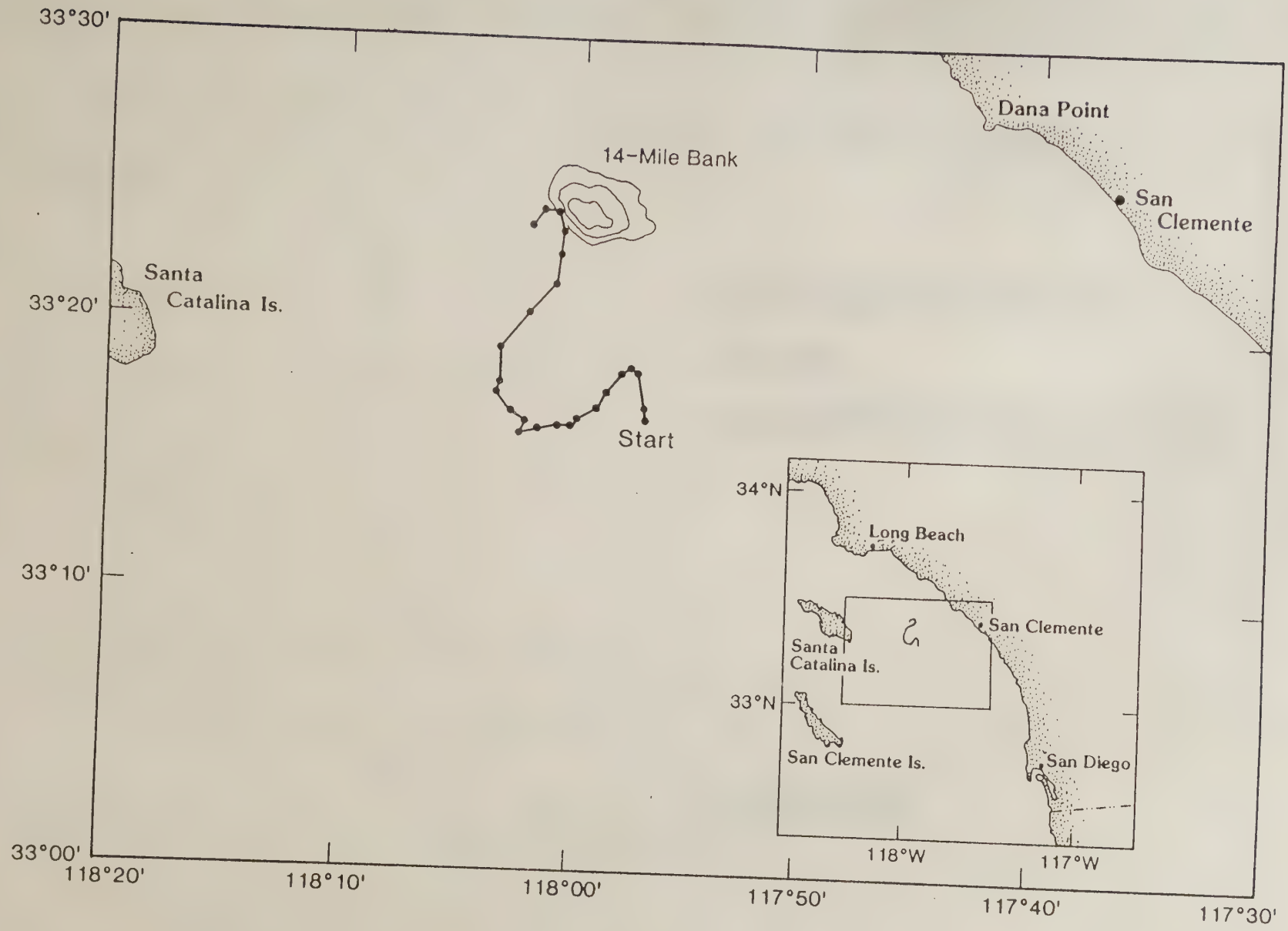

Figure 1. Horizontal movement of swordfish near San Clemente Island. Dots inciate hourly increments.

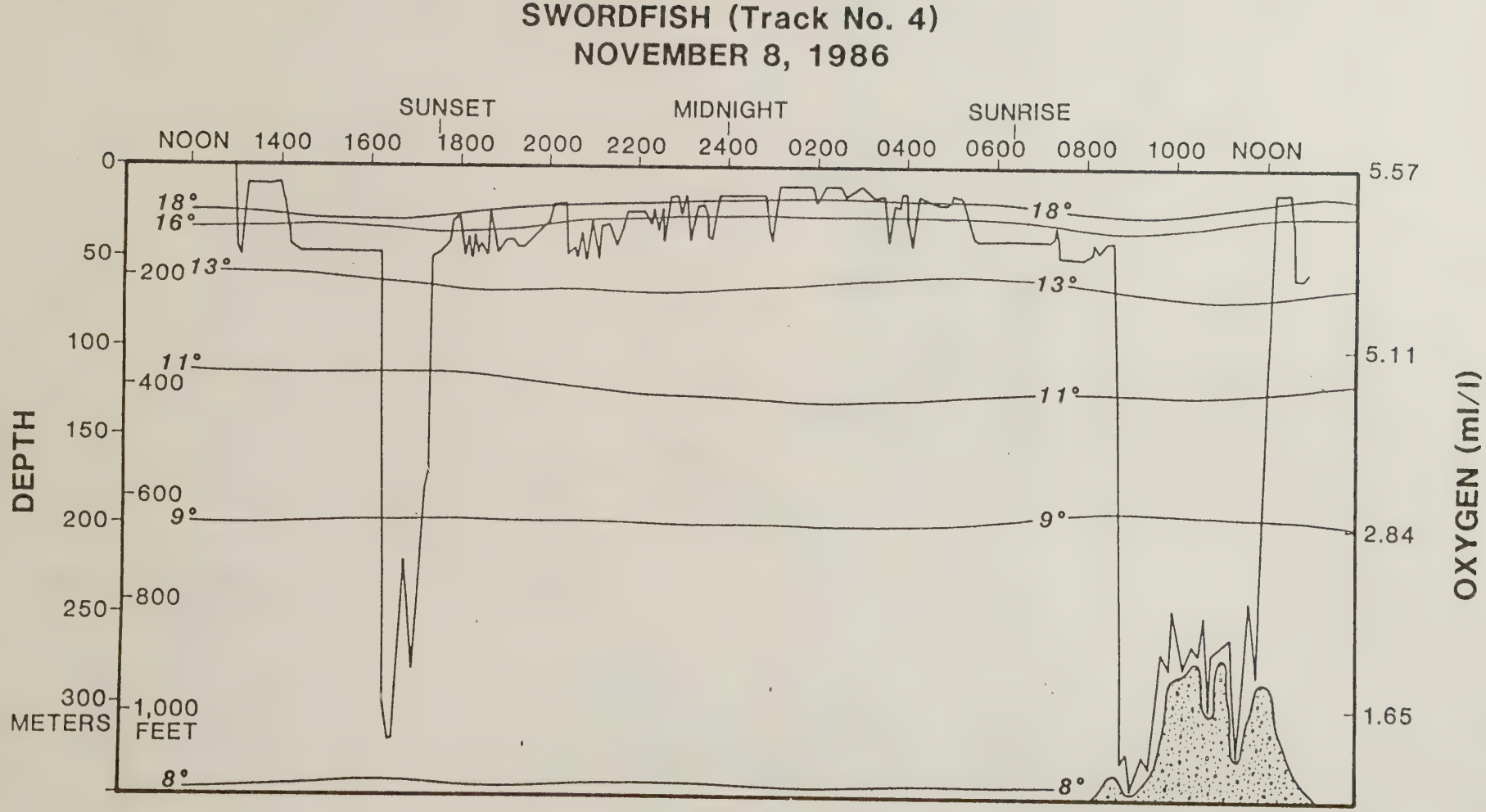

Figure 2. Vertical profile of swordfish activity showing depth, temperature and oxygen concentration. Stippled area after sunrise indicates depth of "14 mile Bank" matched by depth of fish.

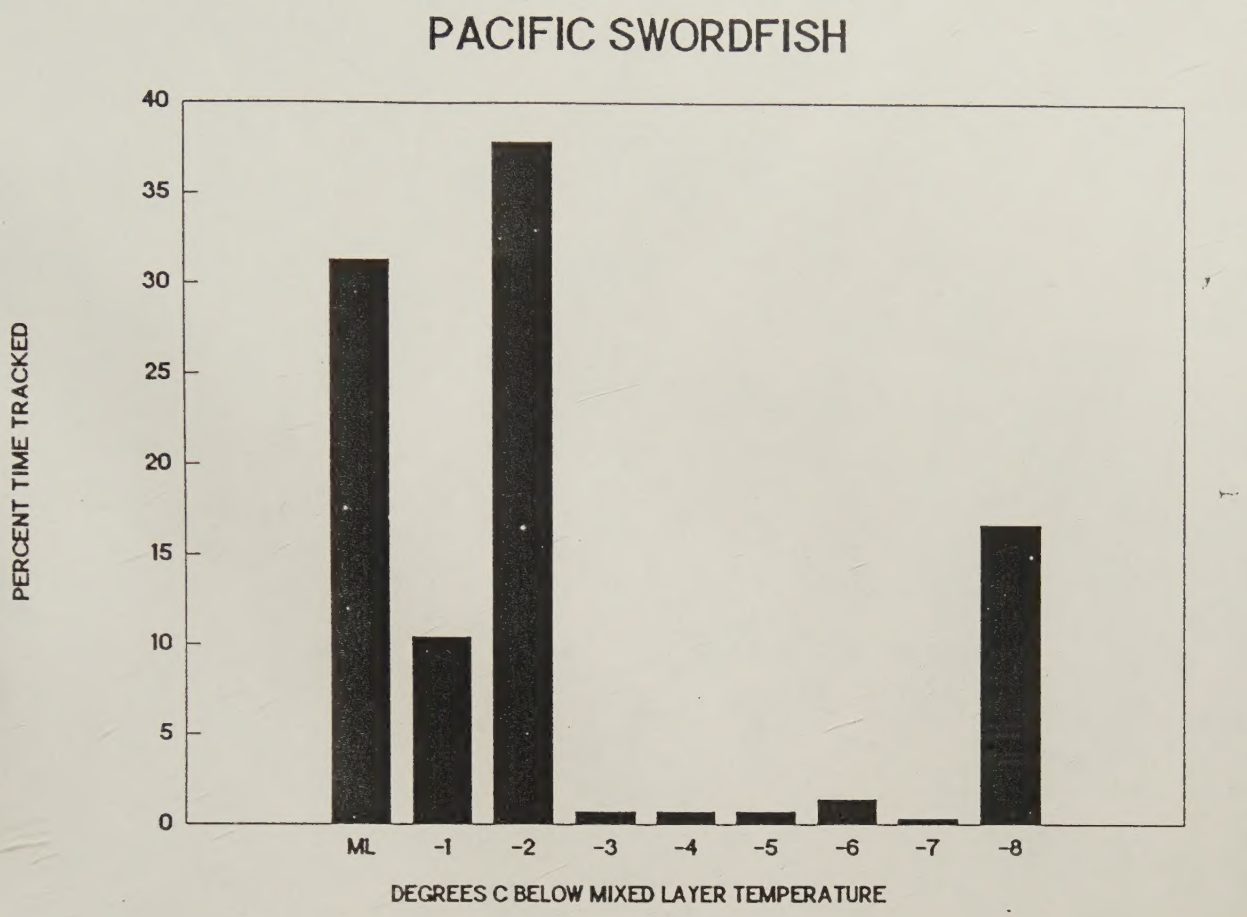

Figure 3. Percent of track time spent at temperatures below that of the mixed layer.